

May 2015 extended essay reports

Mathematics

Overall grade boundaries

Grade:	E	D	C	B	A
Mark range:	0-7	8-15	16-22	23-28	29-36

The range and suitability of the work submitted

Most candidates produced at least a reasonably good essay this year. There seemed to be fewer candidates gaining disappointingly low marks. It is always disappointing to see candidates throw away marks needlessly by not including an abstract, introduction or conclusion, not numbering pages or exceeding 4000 words, for example. Schools are reminded that candidates should have access to the criteria and should be urged to follow them. It is encouraging to know that this is happening in the vast majority of schools.

A common failing in candidates who scored poorly was a tendency to write an essay about mathematics, without actually doing any mathematics. For example candidates might state that there are infinitely many prime numbers rather than proving it. Others might say that the golden ratio is 1.618, rather than derive the exact value by setting up and solving a quadratic equation. It is better to prove an assertion, or if it's a particularly difficult one, explain it in the candidate's own words and give an example to show understanding. Stating a result and identifying the source, or quoting from a source does not show understanding.

A good extended essay will research into an area of mathematics new to the student, or apply their mathematics to a new situation. The starting point should be the mathematics in the candidate's IB Mathematics syllabus, and any mathematics tackled beyond this should be clearly explained, justified or proved in the candidate's own words. Some few candidates were far too ambitious, aiming for degree level mathematics which invariably was poorly explained.

Candidate performance against each criterion

Criterion A: research question

It is usually helpful to candidates to write their chosen topic in the form of a question, it helps them focus their essay. Sometimes a broad topic, rather than a question, such as 'The Mathematics of Cryptography' can result in an unfocussed rambling essay in danger of exceeding 4000 words, and making criteria B and H more difficult. 'How does RSA work?' or 'What is Public Key Cryptography?' might be better.

Criterion B: introduction

It is advisable to head a section 'Introduction', so that the start, and end, of this section are clear, then address the criteria. Candidates should be clear that this is an introduction to their extended essay, explaining what they are researching and why. If the topic itself then requires an introduction, that should be in the next section. For example after the introduction to the EE, an essay on 'What are continued fractions?' might require a section after the introduction which introduces continued fractions.

Criterion C: investigation

Candidates should be aware that there are no hard and fast rules here. A mathematics extended essay could require an extensive bibliography, with plenty of appropriate sources consulted, but equally essays might require appropriate data to be collected and displayed, or might be a purely mathematical investigation where the research question is a problem that interests the candidate (perhaps from an Olympiad paper). In such cases, sources given in the bibliography might be minimal. Candidates can still score highly here if their approach to analysing the data or to solving the problem has been well planned. It is advisable that candidates explain clearly near the start of their essay how they plan to tackle their problem.

Criterion D: knowledge and understanding of the topic studied

It is crucial here that candidates demonstrate understanding of their mathematics. Candidates should avoid quoting from sources, but explain the mathematics in their own words, aim to prove assertions or justify if the proof is too difficult. It is always a good idea to illustrate understanding by an example.

Criterion E: reasoned argument

In mathematics, this criterion can be judged both holistically – does the essay as a whole present a reasoned argument in answering the question? But also, and perhaps more crucially, this criteria is looking at the logical step by step mathematical arguments used. An essay that misses crucial steps in a proof, or states 'it can be shown that....' without actually doing it, will lose out here.

Criterion F: application of analytical and evaluative skills

This criterion depends very much on the nature of the essay, but students who do not clearly explain and justify or prove the mathematics they use will fall down here.

Criterion G: use of language appropriate to the subject:

As well as a holistic judgment, this criterion examines whether candidates ensure the mathematical terminology used is appropriate, for example use of * for multiply or ^ for powers is not appropriate terminology. Similarly a new line should be used for each step in an algebraic argument.

Criterion H: conclusion

Candidates should ensure there is a section clearly labelled 'Conclusion' which addresses the research question.

Criterion I: formal presentation

It is a shame when (relatively few) candidates throw marks away by not addressing factors listed in the criteria. It should also be noted that candidates that do not clearly label graphs, or present their mathematics clearly in a formal mathematical manner may be penalized here.

Criterion J: abstract

Successful candidates write three paragraphs here summarizing what their research question is, how they went about answering it, and the conclusions they reached. It is clear some candidates do not understand what an abstract is and, because it goes at the front of the essay, confuse it with the introduction.

Criterion K: holistic judgement

In many cases, the mark for K may well reflect the marks given particularly in C to G. However, some essays have unusual merit and this can be reflected here. Essays that spring from CAS projects are one example.

Recommendations for the supervision of future candidates

Supervisors should ensure that candidates have access to the criteria and that they understand them. In particular, have candidates write their abstract after writing the essay and ensure they understand what an abstract is. Make sure they give a word count for the essay and a separate one for the abstract. As a line of algebra can take many words to explain, a mathematics essay should, when algebra is not counted, be considerably less than 4000 words. Raw data and questionnaires should go in an appendix, but an appendix should not include material essential for the understanding of the essay. Supervisors should not include their own marks or grades, or any of their own comments on the essay – a clean copy should be submitted.